HW#1 (2025)

(1.) [10 pt] Consider an entropy function

$$S = k(NVE)^{1/3}, \quad \text{where } k = \text{const}$$

and N, V, E are the system's # particles, volume, and total energy, respectively.

Find E^A and E^B for two subsystems at thermal equil. The subsystems can exchange energy but not particles or volume. The subsystems are adiabatically insulated from the outside world.

(2.) [20 pt] Consider ideal gas.

(a) Show that $C_p - C_v = N k_B$

(C_p: specific heat, p = const; C_v: specific heat, V = const; k_B: Boltzmann's const)

(b) Show that

$$\left(\frac{\partial p}{\partial v}\right)_S = -\gamma \frac{p}{V}, \quad \text{where } \gamma = \frac{C_p}{C_v}.$$

(c) Assuming that $\gamma = \text{const}$, derive the law of adiabatics:

$$p T^{\frac{\gamma}{1-\gamma}} = \text{const}.$$

(3.) **10 pt** Show that

$$\gamma = \frac{c_p}{c_v} = \frac{\kappa_T}{\kappa_S}, \text{ where}$$

$\kappa_T = -\frac{1}{V}\left(\frac{\partial V}{\partial p}\right)_T$ is the isothermal compressibility;

$\kappa_S = -\frac{1}{V}\left(\frac{\partial V}{\partial p}\right)_S$ is the adiabatic compressibility.